# MATERIALS PROCESSING

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## UPGRADE OF POLISHING TOOLS BASED ON FIBROUS MATERIALS

**S. K. Mamonov[1] and V. V. Shvaikov[1]**

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The structure of the polishing woolen cloth PTS with 30% content of synthetic fibers is described. The results of its testing with or without special impregnation in treating optical materials are described. The structure and capacity of a spiral polisher are considered.

Polishing tools made of fibrous materials (woolen cloth, felt, etc.) are used to clarify glass plate blocks and other optical elements and to polish surfaces of low-precision optical parts in the absence of stringent color requirements, when the number of rings is ten or more.

The application of such materials has its origin in the earliest production of sheet and optical glass in Russia. The physicochemical aspects of these materials and their operating parameters and wear resistance are summarized in the books by N. N. Kachalov [1, 2] and V. M. Vinokurov [3]. The significant factors include the length and thickness of woolen fibers, their tearing strength and weaving pattern, as well as the cloth density. Fine woolen materials have a higher polishing capacity and in practice fine woolen felt is one of the most commonly used materials: technical felt (GOST 288–72) and prosthesis felt (RF TU 17 17-5414–77).

These materials, initially developed for other purposes, have a nonuniform sheet thickness, a dispersion in densities, and low resistance, and contain scratching solid inclusions. These drawbacks are inherent in the structure of natural felt produced in the fulling-and-felt industry. All this requires periodic dressing of the polisher surface by means of mechanical turning to remove 3 – 5 mm and to bring the plane deviations within 0.05 mm. Together with cutting waste, the total waste of material amounts to 30 – 40%. An increased density and, accordingly, increased resistance of felt polishers was achieved by impregnating them with phenol-formaldehyde lacquer (USSR Inventor's Certif. No. 145151) and then with an acetone solution of this lacquer and butvar-phenolic adhesive.

The substantial consumption of fibrous materials at the company (up to 24,000 m$^2$ per year) called for their upgrade. A technical assignment was based on the data from [4 – 6] and industrial testing of some modifications of polishing wheels based on woolen cloth PSh (RF TU 17 42-5949–87), OF (RF TU 17 42-4793–76) etc. Eventually a special technical cloth PTS (RF TU 17 42-10735–84) was developed for polishing tools (USSR Inventor's Certif. No. 1202839) and its production was implemented at the E. Thalman Fine and Technical Cloth Works (now the Nevskaya Manufaktura Company) in St. Petersburg.

This cloth represents a multilayer woven highly fulled base containing 70% woolen and 30% synthetic fibers. The tissue has a complicated ordered weaving of warp (longitudinal) and weft (lateral) threads that form weaving knots according to a preset program. Cloth PTS has five different weaving patterns: the first four are repeated in each layer and the last pattern is found in one of the outer layers, namely the adhesive lining layer. Such structure joins the woven mass into a single aggregate that has high and uniform tearing strength.

Analysis of available mixtures for impregnating fibrous materials and the experience of developing lubricant-coolants for diamond treatment of glass [7, 8] have made it possible to develop a special mixture for cloth PTS (USSR Inventor's Certif. No. 150890), which contains latex (100 wt. parts) and components from two groups: technical lignosulfonates or carbothymethylcellulose (0.1 – 1.0 wt. parts) and sodium sulfate or silicate (0.5 – 5.0 wt. parts). Technical lignosulfonate can be represented by the byproduct of sulfide cellulose production. After the cloth is impregnated by this mixture with subsequent special drying and vulcanization, the free space between the cloth threads becomes filled. Synthetic latex can uniformly moisten the impregnated material and does not crystallize under the heat treatment. The combination of surfactants and chemically active components raises the wear resistance of the material. In service, the

[1] Lytkarinskii Optical Glass Works, Lytkarino, Moscow Region, Russia.

**TABLE 1**

| Parameter | Felt | | Woolen cloth | | | |
|---|---|---|---|---|---|---|
| | | | | | PTS | |
| | technical | prosthesis | Psh | OF | withou impregnation | with impregnation |
| Tissue thickness, mm | 20 ± 5 | 20 ± 5 | 9 ± 1 | 9 ± 1 | 19 ± 1 | 19 ± 1 |
| Volume density, g/cm$^3$ | 0.41 | 0.43 | 0.45 | 0.38 | 0.50 – 0.60 | 1.00 – 1.20 |
| Tearing load, kN: | | | | | | |
| longitudinal | – | – | 4.00 | 3.75 | 5.00 | 10.50 |
| lateral | – | – | 2.50 | 1.75 | 6.25 | 11.50 |
| Weight of polisher base of diameter 350 mm, kg | 0.80 | 0.83 | 0.40 | 0.33 | 0.74 | 1.20 – 1.50 |
| *Plates from glass LK105* | | | | | | |
| Duration of polishing a block on one side, min | 10 – 12 | 10 – 12 | 10 – 12 | 10 – 12 | 5 – 7 | 3 – 5 |
| Wear resistance until complete wear of the base, shift/article | 8 – 10/246 | 10 – 12/276 | 10 – 12/200 | 8 – 10/132 | 40 – 50/822 | 80/1700 |
| Including articles acceptable at the first check, % | 70 | 70 | 75 | 75 | 95 | 95 |
| Material consumption per article, g | 3.0 | 3.0 | 1.5 | 2.0 | 0.9 | 0.4 |
| *Mesh base from glass K8* | | | | | | |
| Duration of wear, shifts | 8 – 10 | 10 – 12 | – | – | 30 – 40 | 60 – 80 |

components from the first group lower friction between the part being treated and the tool and remove the treatment waste, whereas the components from the second group chemically influence the material treated. It is essential that as the cloth carrier is worn, the impregnation mixture components arrive at the working zone in a preset ratio.

The positive effect of using cloth PTS is seen in Table 1. Its volume density is 1.2 – 1.4 times higher than that of felt of the same thickness. Polisher bases made of this material have abrasive wear existence 4 – 5 times higher and material unit consumption 1.5 – 1.3 times lower than those of felt, woolen cloth PSh, and woolen cloth OF. The impregnation of cloth PTS doubles its advantages.

A comparative study of the materials was carried out in industrial conditions on ShPS-350M machines with the rotational speed of the spindle equal to 274 min$^{-1}$ and 29 double swinging strokes of the lathe carrier. The samples that were polished in separate compartment without pasting included three samples of glass LK105 of size 133.5 × 58.0 mm and finish class VII, and five mesh substrates of diameter 43 mm made of glass K8 with 10 rings, finish class I. The tool was placed from above, and the substrate was fixed to the body from the side of the lining layer by resin using the known method. The steady wear of the working surface, hygroscopicity, and the absence of inclusions makes it possible to use cloth PTS in intense treatment regimes and use the polisher cutting waste shaped as segments and spots in a discontinuous tool. The efficiency of cloth PTS is corroborated by 10 years of service in treating diverse optical and other kinds of materials.

The possibility of application of thin felt-synthetic and polyurethane materials has been investigated on the basis of spiral polisher disks. Based on small-size tools we optimized the structure of 4-mm fine woolen felt for needle ribbons (GOST 11998–76) and 1-mm synthetic technical chamois of grade Polivel (TU 17-21-310–85).

Polishers of diameter 350 mm are produced by cutting the material into ribbons 20 mm wide. A compiled ribbon is treated with surfactants and chemically active materials: 5% aqueous solution of the mixture of sodium silicate and sodium dodecylsulfonate in the ratio of 8 : 1. After drying, a polisher disk is formed by spiral winding of the ribbon between two pairs of clams adjusted to constant tension and the device fixed with one end to the cylinder. As the ribbon is wound, a polishing powder and an adhesive (epoxy resin ED20 with a solidifier and plasticizer) are deposited on this ribbon. The performance of five polishers in treating plates of glass LK105 under the parameters specified above has demonstrated results that are close to the performance of cloth PTS with impregnation (polishing duration 4 – 6 mm, wear resistance 75 – 78 shifts, yield of products acceptable at the fist check — 93 – 94%). The non-worn residual fixing waste is 2 – 3 mm longer, presumably due to the thicker adhesive layer. However, it is possible to make spiral polisher disks of increased height (40 – 50 mm or more) and use them to treat concave and convex spherical surfaces with the corresponding radial turning.

The testing and service results of two types of tools indicate the following:

– the optimal content of synthetic fiber is 30% (in felt this content is 5%);

– the polisher needs to be impregnated along its height by chemically active components and a polishing component.

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